**A relic of the bacterial peptidoglycan synthesis pathway is retained in moss chloroplasts**

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The endosymbiotic theory states that all chloroplasts are derived from a single cyanobacterial ancestor [1, 2]. It is widely agreed that the chloroplasts of red algae and higher plants have no peptidoglycan layer. Therefore, the evolution from endocytobiont into a wall-less, photosynthetic organelle involved a reduction in and loss of the cyanobacterial cell wall, which is of Gram-negative type.

In the moss *Physcomitrella patens*, treatment with ß-lactam antibiotics, which bind penicillin-binding proteins (PBPs) to inhibit peptidoglycan synthesis, results in giant chloroplasts [3, 4]. Treatment with ampicillin, a ß-lactam antibiotic, also led to a decrease in the number of chloroplasts per cell in *Funaria hygrometrica*, and *Polytrichum commune*. These observations suggested that this is a general effect in mosses. Moreover, we showed that antibiotics that inhibited bacterial peptidoglycan synthesis at positions different from ß-lactams also inhibited chloroplast division in *P. patens*. D-cycloserine caused a rapid decrease in the number of chloroplasts per cell and its effect was similar to that of ß-lactam antibiotics. Fosfomycin affected half of the cells, while vancomycin affected a few cells. Conversely, bacitracin had no effect. Since vancomycin and bacitracin mainly inhibit peptidoglycan synthesis in Gram-positive bacteria [5], their minimal effects on chloroplast division may depend on differences in peptidoglycan synthesis between the ancestral Gram-negative-type cyanobacteria and Gram-positive bacteria. Fluorescence microscopic images using fluorescent penicillin suggested that PBPs envelope each moss chloroplast in the same way that they surround bacteria. These findings suggest that a relic of the bacterial peptidoglycan synthesis pathway is retained in moss chloroplasts and is involved in their morphology and division.

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